EFFECT OF 10^{11} PROTON BUNCH ON CAVITY

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Cavity Parameters (p. 167 Design Report)

Peak Voltage	V_o = 360 kV
Frequency	f = 53 MHz ($\omega = 53 \times 2\pi$ MHz)
Unloaded-Q	Q = 6500
Shunt Impedance	Z = 1 MΩ

With these assumed design parameters the cavity performance parameters are then

Cavity Power $\quad\quad P = \dfrac{V_o^2}{2Z} = 64.8$ kW

Stored Energy $\quad\quad W = Q\dfrac{P}{\omega} = 1.265$J

Time Constant $\quad\quad \tau = 2Q/\omega = 39$ μsec

Band Width $\quad\quad\quad \Delta f = f/Q = 8.15$ kHz

Gap Capacitance $\quad C = \dfrac{2W}{V_o^2} = 19.5$ pF $= \dfrac{Q}{\omega Z}$

1. Accelerating 10^{11} proton-bunch ($q = 1.6 \times 10^{-8}$ Coul.) at $\phi_s = 46.8^0$ (75 GeV/sec)

Energy from Cavity per Passage

$\delta W = qV_o \sin\phi_s = 0.0042$J

a. Much smaller than stored energy of 1.265J.

b. Takes the cavity $Q\dfrac{\delta W}{W} = 21.6$ rad or 3.43 oscillations to replenish.

   <u>Loading is no problem.</u> Can stand one 10^{11} bunch every, say, 5 oscillations ($\dfrac{1113}{5} \sim$ 200 bunches).

Voltage Distortion

$\delta V = \dfrac{q}{C} = 820$V

Much smaller than V_o = 360 kV. If bunch is 2 nsec long, voltage distortion slope is $(\delta \dot{V})$ = 410 V/nsec average. $(\delta \dot{V})_{peak}$ may be double, say, 800 V/nsec. Normal rf voltage slope is $V_o \omega\cos\omega t = (120 \times 10^3$ V/nsec) $\times \cos\phi_s$, so rf voltage slope reduction is negligible hence bucket shape distortion is negligible. <u>Voltage distortion is no problem.</u>

II.   Keeping it bunched on flattop is no problem. No beam loading ($\delta W = 0$).
Voltage slope 120,000 V/nsec (at $\phi_s = 0$) is reduced by 800 V/nsec at
max. Negligible!

III.   Numbers indicate that even for 10^{12} proton-bunches the voltage and slope
distortions are tolerable, except it will take 10 times the time to
replenish the energy. Therefore, $\sim$ 20 bunches each 10^{12} protons, evenly
distributed around the ring is OK.

IV.   One 10^{11} bunch every oscillation ($\sim 10^{14}$ p/p) will need a very good feed-
back system to pump energy into the cavity at 3.43 times the "natural"
rate.

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